EPS 253: GLACIOLOGY
PROBLEM SET ONE

(1) Derive the statement of the conservation of internal E using an analysis that parallels the analysis in the lecture notes. Account for these energy sources:
   (a) Shear heating, a heating source that occurs throughout the ice volume, is equal to $\sigma_{ij}\epsilon_{ij}$.
   (b) Conduction, also present throughout the volume, is a heat source q which follows $\nabla \cdot q = -\nabla \cdot (\kappa \nabla T)$, where T is temperature and κ is the ice conductivity.
   (c) The constitutive relationship for internal energy E is $dE/dt = cdT/dt$, where c is the specific heat.

   The result should look like the heat equation. How does this equation couple to the conservation of mass and momentum?

(2) In class we approximated the governing equations to zero order, with the result being the Shallow Ice Approximation. Repeat this analysis, but this time keep one order higher accuracy. In the flow direction momentum balance, this will result in keeping more terms of order ϵ, but still neglecting ϵ^2 terms. Formulate a detailed and rigorous scaling argument. The result is the so called "higher order" ice sheet model.

(3) Download, install, and run the Ice Sheet System Model. Work through the tutorials "Square ice shelf" and "Modeling the Pine Island Glacier". Having done the latter, give a brief ($\sim$ paragraph) intuitive description of the differences that you observe in different stress balance approximations.

(4) Take a look at the excellent Swiss Glacier Education website at http://swisseduc.ch/glaciers. Find photographs that illustrate the stress tensor $\partial\sigma_{xx}/\partial y$ (the lateral derivative of flowline compression), $\partial\sigma_{xz}/\partial z$ (the vertical derivative of shearing on horizontal planes), and $\partial\sigma_{xx}/\partial z$ (vertical gradients of flowline compression).

Due at the beginning of class on Friday, September 28 2018.
Two weeks is more than enough time to do these exercises, so course policy is, "No late homework, No exceptions".